SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Finite Elements in Geotechnical Engineering

Subject Code	**16CGT11**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understand in general how finite elements obtain approximate solutions to differential equations
- Appreciate the structure of a typical finite element program
- Gain experience of finite element analysis applied to classical geotechnical problems (e.g. settlement, seepage, consolidation, slope stability)
- Gain insight into the soil properties needed for finite element analysis

Modules	**Teaching Hours**
Module -1	
Concepts of FEM, Steps involved in Finite Element Analysis Procedure, Merits and Demerits. Principles of Elasticity: Stress equations, Strain-Displacement relationships in matrix form, Plane stress, Plane strain and axi-symmetric bodies of revolution with axi-symmetric loading.	**10 Hours**
Module -2	
Element Properties: Concept of an element, various element shapes, Displacement models, Generalized coordinates, Shape functions, Convergent and Compatibility requirements, Geometric invariance, Natural coordinate system - area and volume coordinates Generation of Element Stiffness and Nodal Load Matrices, Isoparametric Formulation: Concept, Different isoparametric elements for 2D analysis, formulation of 4-noded and 8-noded isoparametric quadrilateral elements, Lagrangian elements, Serendipity elements	**10 Hours**
Module -3	
Discretization of a structure, numbering systems, Aspect ratio its effects, Assemblage, Direct Stiffness method Strain laws: Introduction, Bilinear elastic model, K-G model, hyperbolic model, comparison of models and critical state model (geometric model, hardening law, yield function, flow rule, stress-strain invariant relation, stress-strain component relation, parametric values) with numerical examples	**10 Hours**
Module -4	
Geotechnical Applications Sequential construction, Excavations and embankments, Bearing capacity and Settlement analysis.	**10 Hours**

Module -5	
Geotechnical Applications: Seepage analysis: Finite element discretization of seepage equation, computation of velocities and flows, treatment of free surface boundary, Analysis of jointed rock mass: Characters and discontinuity of rock, model behaviour of jointed rocks, plane strain analysis	**10 Hours**

Course outcomes:

During this course, students will be trained :

- To understand the basic concepts of finite element analysis in general and the transition from structural engineering aspects to geotechnical engineering aspects
- To understand the finite element techniques for seepage analysis and joint rock masses
- In Finite element applications in design and Analysis of bearing capacity of the soil for shallow foundations

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS:

1. Introduction to the Finite Element Method (1972), Desai, C. S. and J.F. , Abel. Van Nostrand Reinhold Company
2. Finite element analysis in geotechnical engineering Vol 1&2, (1999) - D M Potts & L Zdravkovic, Thomas Telford publishing, London
3. Finite element analysis in geotechnical engineering, D J Naylor & g N Pande(2012)
4. Introduction to the Finite Element Method(1993) J. N. Reddy - McGraw-Hill Publishers,
5. Finite element analysis - Theory and programming(1994) Krishna Murthy, C. S. -Tata McGrawHill,
6. Finite element Methods(1971) Zienkiewicz, O. C. -, McGraw-Hill Publishers,

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Theoretical Soil Mechanics

Subject Code	**16CGT12**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- To impart the knowledge for computation of settlements and stress in semi-infinite elastic soil medium
- settlements and stress in anisotropic medium and layered deposits due to foundation loads
- Concept on plastic collapse.

Modules	**Teaching Hours**
Module -1 Introduction – Elasticity and stability problems, concept of stress and strain – plane stress, plane strain and axisymmetric problems – equation of equilibrium and compatibility – stress functions.	**10 Hours**
Module -2	
Stresses in elastic half-space medium by external loads – fundamental solutions –Boussinesq, Flamant, Kelvin and Mindlin solution – Applications of fundamental solutions – Anisotropic and non-homogeneous linear continuum – Influence charts - elastic displacement-layered soil-Burmister method	**10 Hours**
Module -3	
Limit equilibrium analysis – perfectly plastic material – stress – strain relationship –stress and displacement field calculations – slip line solutions for undrained and drained loading, arching of soils and theories of arching	**10 Hours**
Module -4	
Limit analysis – principles of virtual work – theorems of plastic collapse – Mechanism for plane plastic collapse – Simple solutions for drained and undrained loading –stability of slopes, cuts and retaining structures. Centrifuge model – Principles and scale effects, practical considerations	**10 Hours**
Module -5	
Flow through porous media – Darcy's law – General equation of flow – steady state condition – solution by flow net – fully saturated conditions; Yielding, Bounding Surfaces	**10 Hours**

Course outcomes:

During this course, students will be trained :

- to evaluate the theoretical aspects like stresses, limiting stresses etc
- To understand the stability aspects collapse mechanisms, centrifuge modeling, Estimate the stresses in soils, Flow net and related problems

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Foundations of Theoretical Soil Mechanics, Harr, M.E (1966) McGraw Hill,
2. Foundation Engineering Handbook, Winterkorn, H.F., and Fang, H.Y(2000) Galgotia, Booksource, 2000
3. Theoretical Soil Mechanics- Karl Terzaghi (1943), John Wiley & Sons.
4. Soil Mechanics and Foundations, Muniram Budhu(2007), John Wiley & Sons, Inc.

Reference Books:

1. Soil Mechanics, T.W. Lambe and R.V. Whitman (1969). John Wiley & Sons,.
2. Foundations and slopes- Attikinson (1981), McGraw Hill, New Delhi
3. Seepage, Drainage and Flownets – Cedergren H R(1997).-, John Wiely & Sons
4. The Mechanics Basic concepts and Engineering Applications- Aysen A (2002), AA Balkema Publishers, 2002

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Subsurface Investigation and Ground Improvement Techniques

Subject Code	**16CGT13**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the soil type of soil from a job site or in a professional setting, determine that soil's properties based on type and evaluate design decisions from your understanding of that soil's properties.
- To explore the scientific principles used to describe the major engineering properties of soil, and the engineering testing methods used to quantify these properties
- To explore the site improvement techniques

Modules	**Teaching Hours**
Module -1 **SITE INVESTIGATION:** Planning of Exploration and experimental programme, investigations, exploration for preliminary design, exploration for detailed design Geo-physical explorations (soundings, probings, boring, boring methods), excavation methods for explorations, ground water investigations, rock boring, miscellaneous exploratory techniques	**10 Hours**
Module -2	
SAMPLING AND IN-SITU FIELD TESTS: Types of samples, samplers, preservation, shipment and storage of samples, bore log, pore pressure measurements, core recovery, rock strength, rock quality designation In-situ field testing and laboratory investigation of soils and rock (including advanced equipment), instrumentation, data acquisition and measurement techniques: SPT, SCPT, DCPT, pressuremeter, dilatometer, permeability, plate load test, lateral pressure test. Numerical problems	**10 Hours**
Module -3	
DATA INTERPRETATION: Data interpretation for determination of engineering properties of soils and their application to geotechnical design, preparation of site investigation reports	**10 Hours**
Module -4	
SITE IMPROVEMENT: General methods of stabilization – shallow and deep, factors governing suitable method, compaction, Drainage: soil and filter permeability, filter criteria, drainage layout and pumping system, Pre-compression and consolidation: principles, sand drains, pore pressure distribution, electro-osmotic and chemical osmotic consolidation. Numerical problems	**10 Hours**
Module -5	
STABILIZATION: Mechanical stabilization, lime, cement, bitumen,	**10 Hours**

chemical etc. Grouting: Injection and principles, grouting pressure criteria, grouting equipment, injection chemicals, Thermal methods: heating and cooling effects on soils, equipment, Miscellaneous: moisture barriers and preventing techniques	

Course outcomes:

During this course, students will be trained:

- To explore and understanding the behaviour of soils using index, compaction and engineering properties for the design of foundations.
- To adopt suitable f ground improvement techniques to alter the geotechnical properties to suit any type of foundations based on the load coming from the super structure on to the foundation and soil

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Engineering Principles of Ground Modifications – Hausmann, McGraw Hill.
2. Foundation Analysis and Design – J E Bowles, Tata McGraw Hill.
3. Subsurface Exploration and Sampling of Soils for Civil Engg. Purposes – Hvorslev M J,

Reference Books:

1. Soil Mechanics, T.W. Lambe and R.V. Whitman. John Wiley & Sons, 1969.
2. Geotechnical Engineering- Donold P Coduto Phi Learning Private Limited, New Delhi
3. Geotechnical Engineering- Shashi K. Gulathi & Manoj Datta. (2009), "Tata Mc Graw Hill.
4. Soil Mechanics and Foundation Engg.- Muni Budhu (2010), 3rd Edition, John Wiely & Sons
5. Soil Mechanics for Road Engineers - HMSO

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Design of Shallow Foundations

Subject Code	**16CGT14**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understanding the capacity of the soil under different field conditions
- Design of shallow foundations under different loading condition and different environment
- Design of footings for uniform settlement of all shallow foundations.

Modules	**Teaching Hours**
Module -1	
Developments - need of Foundation Engineering - Responsibility of Foundation Engineer - Classification - General requirements - Additional consideration - selection of type of foundation - hostile environment - structural integrity – economy, foundation drainage and water proofing	**10 Hours**
Module -2	
Bearing capacity of shallow foundations - Homogeneous - Layered soils - Soft and Hard Rocks, effect of ground water table and eccentricity of foundations Evaluation of bearing capacity from in-situ tests - partial safety factor approach codal - Recommendations. Settlement analysis-immediate-consolidation settlement-layered soil and rocks-construction period correction-evaluation from in-situ tests - code recommendations.	**10 Hours**
Module -3	
Foundations on sanitary landfill site, residual soils, permafrost and adjoining to the river bed Contact pressure under footings – Contact pressure under rigid rectangular footing, strip foundation, rigid circular footing, Principles of footing design, Design of non – rigid combined footings Including structural detailing	**10 Hours**
Module -4	
Proportionating of shallow footings, Introduction to special foundations - Foundation design in relation to ground movements - Foundation on recent refuse fills - Design of Foundation for seismic forces - Codal recommendations - Introduction to theory of vibration - Design of Block foundation - Codal recommendations.	**10 Hours**

Module -5	
Design of Raft foundations- types of rafts, stability and rigidity of the soil structure system, allowable soil pressures for rafts in cohesionless and cohesive soils, Design of raft by rigid beam method and Winkler method, Solution based on elastic half space and based on elastic theory.	**10 Hours**

Course outcomes:

During this course, students will be trained to:

- Analyse the bearing capacity of the soil for shallow foundations
- Design aspects of Raft foundations for achieving uniform settlement for special structures like water tanks
- Structural design of shallow foundations in all conditions like land-fills, pavements etc in varying conditions including seismic areas
- Proper communication with structural and other engineers

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Foundation Engineering, Verghese P C. (2011)– PHI, India
2. Foundation Engineering Teng (1992)- PHI, India
3. Foundation Engineering, Bajra M Das.(2012), Cengage Learning India
4. Foundation Analysis and Design , J E Bowles(2012), McGraw Hill, Inc.

Reference Books:

1. Foundation Engineering, Peck hanson & Thronburg(1974). John Wiley & Sons,.
2. Analysis and design of Subsructures- Swami Saran (2009), Oxford & IBH
3. Foundation Engineering Naryana S Naik(2012), Dhanphat Rai publishers, New Delhi
4. Geotechnical Engg.- Purushothamraj (2010), Tata McGraw Hill

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Pavement Analysis and Design

Subject Code	16CGT151	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the type of pavement and to know the stress distribution
- Learn the deflection criteria in soils for different pavements
- To know the characteristics of the rigid pavements and flexible pavements

Modules	Teaching Hours
Module -1 **INTRODUCTION:** Types and component parts of pavements, factors affecting design and performance of pavements, highway and airport pavements	**8 Hours**
Module -2	
STRESSES AND DEFLECTION IN FLEXIBLE PAVEMENTS: Stresses and deflections in homogeneous masses, two, three and multi-layer theories, wheel load stresses, various factors in traffic wheel loads, ESWL of multiple wheels, repeated loads and EWL factors, sustained loads, pavement behaviour under transient traffic loads	**8 Hours**
Module -3	
FLEXIBLE PAVEMENT DESIGN METHODS FOR HIGHWAYS AND AIRPORTS: Empirical, semi-empirical and theoretical approaches, development, principle, design steps, advantages and application of the different pavement design methods including IRC, AASHTO and Asphalt Institute methods	**8 Hours**
Module -4	
STRESSES AND DEFLECTIONS IN RIGID PAVEMENTS: Types of stresses and causes, factors influencing the stresses, general considerations in rigid pavement analysis, EWL, wheel load stresses, warping stresses, frictional stresses, combined stresses	**8 Hours**
Module -5	
RIGID PAVEMENT DESIGN: Types of joints in cement concrete pavements and their functions, joint spacing, design of CC pavement for roads and runways, design of joint details for longitudinal joints, contraction joints and expansion joints, IRC method of design by stress ratio method, Design features of CRCP, SFRC and ICBP, Problems, design of continuously reinforced concrete pavements	**8 Hours**

Course outcomes:

During this course, students will be trained :

- For the design of flexible and rigid pavements at different soil conditions
- To understand the behaviour of the stresses and deflections at different loading and soil conditions

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Principles of Pavement Design – Yoder E J, Witczak, John Wiley and Sons
2. Soil Mechanics for Road Engineers – RRl and DSIR, HMSO Publication
3. Design of Functional Pavements – Huang, McGraw Hill Book Co.
4. Development in Highway Engineering – Pell Peter S, Applied Science Publishers, London
5. Pavement Analysis – Huang, Elsever Publications

Reference Books:

1. IRC Publications
2. CMA Handbook

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Case Histories in Geotechnical Engineering

Subject Code	**16CGT152**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understanding the failure mechanism in geotechnical engineering
- Evaluating the soil as different construction materials and its behaviour
- Role of soil in past and future in construction industry

Modules	**Teaching Hours**
Module -1 Geotechnical problems in civil engineering and in foundations. Soil as construction material in slopes and excavations. Geotechnical problems in underground and earth retaining structures**.**	**8 Hours**
Module -2	
Behaviour of different soils under different foundations and different environmental conditions. Calculated risk and safety factors in applied soil engineering	**8 Hours**
Module -3	
Past and future of applied soil mechanics, Effect of pore water pressure	**8 Hours**
Module -4	
New concepts in consolidation settlements, settlements and bearing capacity	**8 Hours**
Module -5	
Case histories- typical cases of performance failure of representative of soil engineering projects namely shallow and deep foundations, slope stability, earth dams, retaining structures , machine foundations etc.,	**8 Hours**

Course outcomes:

During this course, students will be trained:

- To develop a model for the behaviour of the soil from the existing or past data.
- To prediction the failures based on the material and soil behaviour
- To develop new approaches for design of stable structures by understanding the case histories for failure of foundation structures and arrive at classical geotechnical behaviour to contract the failures

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Fundamentals of soil behaviour – J K Mitchel. (2012)- McGraw- Hill Co.
2. Soil Mechanics SI version- Lambe, T. W. and Whitman, R. V, .(2011) John Wiley & Sons
3. Soil Mechanics and Foundations, Muniram Budhu(2011), John Wiley & Sons, Inc.
4. Soil Mechanics, JE.Bowles (2012), McGraw Hill

Reference Books:

1. Soil Mechanics, Terzaghi and Peck (1969). John Wiley & Sons,.
2. Geotechnical Engineering- Donold P Coduto Phi Learning Private Limited, New Delhi
3. Literatures for Case Histories from known Journals (ASCE, Elsevior, Canadian Geotechnical Journal etc.,)
4. Soil Mechanics- J A Knappett and R F Craig Eighth Edition(2012), Spon Press Taylor & Francis

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Theory of Elasticity and Plasticity

Subject Code	**16CGT153**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understand the fundamentals of the continuum mechanics of solids
- Understand the failure criteria with focus on plasticity
- Understand the relationship between mechanical behaviour of solids and their underlying microstructure
- Enable students to select appropriate constitutive theory for finite element analysis.

Modules	**Teaching Hours**
Module -1 **ELASTICITY:** Theory of Elasticity vs ordinary mechanics, concept of homogeneity, anisotropy, isotropy and orthotropy, generalized Hook's law, ideal stress – strain diagram for rigid, plastic and viscous materials. Numerical Problems	**8 Hours**
Module -2	
PRINCIPAL STRESSES AND STRAINS: Notation for forces and stress components of stresses and strain, plane stress and plane strain, principal stress and strain, maximum shear stress, and shear planes, Mohr circle of stress and strain, strain rosettes Differential equations of equilibrium, boundary conditions, compatibility equations and stress functions. Numerical Problems	**8 Hours**
Module -3	
PLANE STRESS AND PLANE STRAIN: Two-dimensional problems rectangular coordinates, displacement and deformation, St. Venant's and Prandtl's theories, determination of displacements Two-dimensional problems in polar coordinates – governing equations, stress distribution symmetric about axis. Numerical Problems	**8 Hours**
Module -4	
THEORY OF PLASTICITY: Crystal Grains, mechanics of plastic deformation, consecutive stages of deformation: elastic and plastic deformation and fracture, inelastic deformation, factors affecting plastic deformation, strain hardening, stress-strain relationship, Tresca and VonMises criterion of yielding. Numerical Problems	**8 Hours**
Module -5	
Viscoelastic material: Maxwell body, Kelvin Voigt body, linear standard body **Theories of failure:** maximum principle stress theory, maximum principle strain theory, strain energy theory, distortion energy	**8 Hours**

theory, distortional energy, maximum shear stress theory. Numerical Problems	

Course outcomes:

During this course, students will be trained to:

- Idealize the criteria governing the failure of soil in elastic and plastic states
- Provide better solutions to the problems of the soil related to deformation

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Theory of Elasticity – S Timoshenko and J N Goodier, McGraw Hill.
2. Theory of Elasticity – Sadhu Singh, Khanna Publication.
3. Applied Elasticity – T G Sitaram and L Govindaraju, Interline Publication, B.lore
4. Plasticity for Structural Engineers – Chen W F and Han D J (2000), Springer-Verlag
5. Engineering Plasticity – Slater R A C (1977), John Wiley and Sons, NY
6. Fundamentals of Plasticity – Kachanov (1974)

Reference Books:

1. Photo Elasticity - Frocht.
2. Mechanics of Materials – Hearn E J (1985), Pergamon Press, Oxford
3. Introduction to Solid Mechanics – Irving H Shames and James M Pitarresi, Prentice Hall of India
4. Theory of Plasticity – Chakrabarty (1987)

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Advanced Soil Mechanics

Subject Code	**16CGT154**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students :

- To explore the scientific principles used to describe the major engineering properties of soil, and the engineering testing methods used to quantify these properties
- To explain role of water in soil behavior with change in soil stresses, permeability and quantity of seepage including flow net are estimated
- To determine shear parameters and stress changes in soil due to foundation loads
- To estimate the magnitude and time-rate of settlement due to consolidation

Modules	**Teaching Hours**
Module -1 Geostatic Stresses & Stress Paths: Stresses within a soil mass: Concept of stress for a particulate system, Effective stress principle, Geostatic stresses, Soil water hydraulics: Principal stresses and Mohr's circle of stress, Stress paths; At Rest earth pressure, Stress paths for different practical situations	**8 Hours**
Module -2	
Compressibility and Consolidation: One, two and three dimensional compression, Oedometer test, parameters – coefficient of volume change, constrained modulus, compression index, swell for loading and unloading, maximum past consolidation stress, Overconsolidation ratio, Primary and secondary compression, consolidation -One, two and three dimensional problems, Consolidation of partially saturated soils, Creep/Secondary Consolidation	**8 Hours**
Module -3	
Stress-Strain-Strength Behaviour of Soils: Shear strength of soils; Failure criteria (Four Models for interpreting the shear strength of soils- Coulomb's Failure Criterion, Taylor's Failure Criterion, Mohr–Coulomb Failure Criterion, Tresca Failure Criterion, Practical Implications of Failure Criteria), drained and undrained shear strength of soils. Significance of pore pressure parameters; Determination of shear strength; Drained, Consolidated Undrained and Undrained tests; Interpretation of triaxial test results. Behaviour of sands; Critical void ratio; dilation in soils	**8 Hours**
Module -4	

Stability analysis of slope -effective vs. total stress analysis, Stability Analysis of Slope: Effective and total stress approach, shape of slip surface, methods of slices, graphic methods, location of critical slip circle, wedge analysis method, stability during critical conditions. Soil Anchors: Inclusions and Installation Techniques, Design of Soil Anchors, Application Criteria: Advantages and Limitations:	**8 Hours**
Module -5	
Critical State Soil Mechanics: Critical state parameters; Critical state for normally consolidated and over consolidated soil; Significance of Roscoe and Hvorslev state boundary surfaces; Yielding, Bounding Surfaces	**8 Hours**

Course outcomes:

During this course, students will be trained:

- Analyse the soil stresses, permeability and seepage for the existing field conditions
- To understand the compressibility behaviour of soil and consolidation settlement along with time rate of settlement
- To develop suitable method for analyzing the slope stability.
- To understand the behaviour of soils at critical state

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. An Introduction to the Mechanics of Soils and Foundation - through critical state soil mechanics- Atkinson J. H. - McGraw- Hill Co. (1993)
2. Soil Behavior and Critical State Soil Mechanics Wood, D.M (1991)- cambridge university press
3. Soil Mechanics SI version- Lambe, T. W. and Whitman, R. V, John Wiley & Sons.(2011)
4. Soil Mechanics and Foundations, Muniram Budhu(2007), John Wiley & Sons, Inc.

Reference Books:

1. Geotechnical Engineering- Donold P Coduto Phi Learning Private Limited, New Delhi
2. Soil Mechanics and Foundation Engg.- Muni Budhu (2010), 3rd Edition, John Wiely & Sons
3. Soil Mechanics- J A Knappett and R F Craig Eighth Edition(2012), Spon Press Taylor & Francis

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject: Advanced Geotechnical Engineering Lab -1

Subject Code	**16CGTL16**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	42	Exam Hours	03

CREDITS – 02

Course objectives: This course will enable students to

- The objective of this course is to make students to learn principles and design of experiments.
- To investigate the performance of various Soils

Modules	**Teaching Hours**
Determination of specific gravity and moisture content	**3 hours**
Determination of in-situ density	**3 hours**
Wet sieve analysis and hydrometer analysis	**3 hours**
Determination of Atterberg's Limits	**9 hours**
Determination of OMC and MDD (standard and modified Proctor)	**6 hours**
Determination of coefficient of permeability (variable head method and constant head method)	**3 hours**
Determination of shear parameters from shear tests (Direct, UCC, Triaxial)	**9 hours**
California bearing ratio	**3 hours**

Course outcomes:

During this course, students will be trained :

- Achieve Knowledge of Design and development of experimental skills.
- Understand the principles of design of experiments.

Question paper pattern:

- Individual experiments can be set as single experiment
- All questions are to be framed such that they should relate to field

Text Books:

1. Shamsher Prakash, (1979) "Engineering Soil Testing ", Nemichand, New Delhi.
2. Joesph E Bowles, "Engineering Properties of soil and their measurements", McGraw hill

Reference Books:

1. John T. Germaine, Amy V. Germaine, (2009) "Geotechnical Laboratory Measurements", John Wiely
2. William Lambe, (2003) "Soil Tsting for Engineers", MIT.

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Soil Dynamics

Subject Code	**16CGT21**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- To study vibration concepts in soils like damping, wave propagation, resonance and effect of modes of vibrations
- To study dynamic soil properties. Determination of dynamic properties by field and laboratory tests
- Effect of liquefaction and antiliquifaction measures
- To study vibration isolation, machine foundation design

Modules	**Teaching Hours**
Module -1 Fundamentals of Vibration: Definitions, Simple harmonic motion, Response of SDOF systems of Free and Forced vibrations with and without viscous damping, Frequency dependent excitation, Systems under transient loads, Rayleigh's method of fundamental frequency, Logarithmic decrement, Determination of viscous damping, Transmissibility, Systems with Two and Multiple degrees of freedom, Vibration measuring instruments.	**10 Hours**
Module -2	
Wave Propagation and Dynamic Soil Properties: Propagation of seismic waves in soil deposits - Attenuation of stress waves, Stress-strain behaviour of cyclically loaded soils, Strength of cyclically loaded soils, Dynamic soil properties - Laboratory and field testing techniques, Elastic constants of soils, Correlations for shear modulus and damping ratio in sand, gravels, clays and lightly cemented sand. Liquefaction of soils: An introduction and evaluation using simple methods	**10 Hours**
Module -3	
Vibration Analyses: Types, General Requirements, Permissible amplitude, Allowable soil pressure, Modes of vibration of a rigid foundation block, Methods of analysis, Lumped Mass models, elastic half space method, elasto-dynamics, effect of footing shape on vibratory response, dynamic response of embedded block foundation, Vibration isolation	**10 Hours**
Module -4	
Design of Machine Foundations: Analysis and design of block foundations for reciprocating engines, Dynamic analysis and design procedure for a hammer foundation, IS code of practice design procedure for foundations of reciprocating and impact type	**10 Hours**

machines. Vibration isolation and absorption techniques	
Module -5	
Machine Foundations on Piles: Introduction, Analysis of piles under vertical vibrations, Analysis of piles under translation and rocking, Analysis of piles under torsion, Design procedure for a pile supported machine foundation	**10 Hours**

Course outcomes:

During this course, students will be trained :

- To develop a mechanism to design the foundations for resisting vibrations and achieve static equilibrium conditions of structures
- To understand the classical geotechnical failures due to liquefaction and mitigate the same.
- Design of foundations in large structures like power plants, other industrial buildings etc., for analysing the vibrating waves which can be isolated and measures for achieving safety of the adjacent foundations

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Soil Dynamics and Machine Foundation (2010), Swami Saran, Galgotia Publications Pvt. Ltd.
2. Soil Dynamics(1981)- Prakash, S. McGraw Hill Book Company

Reference Books:

1. Foundation for Machines (1998) Prakash, S. and Puri, V. K.: Analysis and Design, John Wiley & Sons,
2. Vibration Analysis and Foundation Dynamics(1998)-Kameswara Rao, N. S. V., Wheeler Publication Ltd.,
3. Vibrations of Soils and Foundations(1970) Richart, F. E. Hall J. R and Woods R. D., Prentice Hall Inc.,
4. Principles of Soil Dynamics (2002) Das, B. M., PWS KENT publishing Company, Boston.

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject: Unsaturated Soil Mechanics

Subject Code	**16CGT22**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understand concept of shear stress and its importance
- Know the behaviour hydraulic conductivity of the soil
- Know the importance of soil-water interaction in applied soil engineering

Modules	**Teaching Hours**
Module -1 **Introduction to Unsaturated Soil Mechanics**: Types of problems, typical profiles of unsaturated, tropical and residual soil, expansive and collapsing type of soils. Origin and formation, identification and classification of expansive and collapsing soils, Contractile skin. **Collapse and Heave:** Collapse potential and swell potential, importance and their determination by different laboratory methods, Heave prediction based on oedometer tests, suction tests and empirical procedures, heave and collapse settlement	**10 Hours**
Module -2 **Soil Suction:** Matric and osmotic suction, total suction, theory of soil suction, measurement by direct and indirect methods – Tensiometers, Axis translation technique, Pressure plate apparatus, Filter paper method, Psychrometers, Squeezing technique of measuring osmotic suction **Flow through unsaturated soils** – flow laws, Darcy's law for unsaturated soils, coefficient of permeability with respect to water phase and air phase, air diffusion, measurement of permeability and air coefficient of permeability	**10 Hours**
Module -3 **Phase properties and relations for unsaturated soils:** Properties of individual phases, interaction of air and water, volume-mass relations, changes in volume-mass properties, densities of mixtures subjected to compression of the air phase, piston porous stone analogy, effective stress concepts and stress state variables for unsaturated soils, equilibrium analysis for unsaturated soils: total or overall equilibrium, independent phase equilibrium – water phase, air phase, contractile skin(meniscus)	**10 Hours**
Module -4 **Design alternatives for structures on expansive soils:** Structural	**10 Hours**

foundation alternatives, treatment of expansive soils – general considerations and guidelines, surcharge loading, prewetting, use of admixtures, electrochemical soil treatment, moisture control and soil stabilization, treatment alternatives for highways and airfield pavements.	
Module -5	
Shear strength: History of shear strength, failure envelope for unsaturated soils, use of effective stress parameters to define shear strength, Mohr-coulomb and stress points envelopes, triaxial tests on unsaturated soils, CD tests, constant water content tests, CU tests with pore pressure measurements, undrained tests, multistage testing, measurement of shear strength parameters	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To understand the concept of unsaturated soils and change in the behaviour of the soil properties
- To understand the contractual skin mechanism of partially saturate sols in the design of foundations by knowing the soil water interaction i.e., soil as a four phase system. Comparative study of basic properties in case of three and four phase system in soils
- To design the effective methods for foundations and structures

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Soil Mechanics for Unsaturated Soils – DG Fredlund and H Rahardjo, Wiley Interscience Publication, John Wiley & Sons, NY
2. Unsaturated Soil Mechanics – Ning Lu and William J Likos, John Wiley & Sons, INC

Reference Books:

1. Mechanics of Residual Soils – G E Blight, A A Balkema Publishers, USA
2. Expansive Soils – Problems & Practice in Foundations and Pavement Engineering – John D Nelson and Debora J Miller, John Wiley & Sons, NY

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Design of Deep Foundations

Subject Code	**16CGT23**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Know the design of deep foundation
- Type of deep foundations will be provided for different structures
- Understand the special foundations.

Modules	**Teaching Hours**
Module -1 Single Pile: Vertically loaded piles, Static capacity- α, β and λ Methods, Dynamic formulae; Wave Equation Analyses; Point Bearing Resistance with SPT and CPT Results; Bearing Resistance of Piles on Rock; Settlement; Pile Load Test; Uplift Resistance; Laterally Loaded Piles -Ultimate Lateral Resistance; Negative Skin Friction; Batter Piles; Under Reamed Piles; Mini and Micro Piles.	**10 Hours**
Module -2	
Buckling of Fully and Partially Embedded Piles; Ultimate Capacity of Pile Groups in Compression, Pullout & Lateral Load; Efficiency; Settlements of Pile Groups; Interaction of Axially & Laterally Loaded Pile Groups	**10 Hours**
Module -3	
Pile Raft foundation: design criteria Design of Sheet pile foundations: Analysis of anchored sheet piles and cantilever sheet piles Lateral supports in open cuts Numerical problems	**10 Hours**
Module -4	
Well Foundation: Design and construction. Bearing capacity, settlement and lateral resistance. Tilts and shifts. Drilled Shaft: Construction procedures, Design Considerations, Load Carrying Capacity and settlement analysis	**10 Hours**
Module -5	
Special Topics of Foundation Engineering Foundations on Collapsible Soils: Origin and occurrence, Identification, Sampling and Testing, Preventive and Remedial measures. Foundations on Expansive Soils: The nature, origin and occurrence, Identifying, testing and evaluating expansive soils, typical structural distress patterns and Preventive design & construction measures.	**10 Hours**

Course outcomes:

During this course, students will be trained :

- to analyse and adopt design skills of vertical and batter piles for various types of loading and soil conditions
- To design the sheet piles and under reamed piles in expansive soils.
- to design the well foundations (caissons)

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Analysis and design of Substructures (2009), Swami Saran, Oxford & IBH Publications Pvt. Ltd.
2. Foundation design in practices (2010)- Kaurna Moy Ghosh. PHI
3. Foundation engineering (2012)- J E Bowles, McGraw Hill

Reference Books:

1. Pile Foundation Analysis and Design H.G. Poulos, and E.H.Davis, John Wiley and Sons, New York.
2. Design of Foundation Systems (1992)N.P. Kurien: Principles & Practices, Narosa, New Delhi
3. Foundation Engineering Hand Book (1990), H. F. Winterkorn and H Y Fang Galgotia Booksource

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Earth and Earth Retaining Structures

Subject Code	**16CGT24**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- To study the geostatic stresses, shear strength of soils.
- To study the static earth pressure for retaining walls, slope stability etc

Modules	Teaching Hours
Module -1 **Geostatic Stresses:** Total, neutral and effective stress in homogeneous soils, stress diagrams, stresses effected by Capillary water and direction of flow of water. Numerical problems **Shear Strength of Soils:** Introduction, concept of stresses, Principal stresses, principal planes, Mohr's construction, location of pole, basic concept of shearing resistance, Coulomb's theory, Mohr-Coulomb's theory. Numerical problems	**10 Hours**
Module -2	
Determination of Shear strength parameters, stress controlled and strain controlled tests, classification of shear tests based on drainage conditions, stress-strain relationship of clays and sands, concept of critical void ratio, determination and uses of Skempton's pore pressure coefficients A and B experimentally. Numerical problems	**10 Hours**
Module -3	
Earth Pressure: Introduction, active and passive earth pressures, earth pressure at rest, Rankine's theory for determination of active and passive earth pressure, coefficient of earth pressure at rest, earth pressure distribution, total earth pressure and its point of application, determination of tension cracks and critical height for unsupported excavation, effect of water table on earth pressure, Coulomb's theory of active and passive earth pressure, Culmann's and Rebhann's graphical methods for determination of active and passive earth pressures, earth pressure calculations for line load and/or uniform strip load acting on the ground surface	**10 Hours**
Module -4	
Stability of Slopes: Introduction, Factor of Safety, slope failure, toe and base failure of finite slopes, analysis of stability by method of slices, Taylor's stability number, effect of water table on slopes, tension cracks	**10 Hours**

Module -5	
Seepage Analysis: Laplace's equation for two dimensional flow of water through soils, flownets, properties and uses of flownets, phreatic line, graphical and analytical procedures for determination of quantity of seepage, prevailing hydraulic head and exit gradient in homogeneous earth dam, uplift pressure, sketching of flownets for typical hydraulic structures – weirs, dams, sheet pile walls	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To analyse the field problems and encountering various failures due to shear geostatic stress etc
- To design the and analyze the retaining structures for earth pressures
- To design and analyse suitable slope stability, understand the seepage in soils for design of complicated structures

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Foundation analysis and design - J E Bowles, McGraw Hill, NY
2. Soil Mechanics in Engineering Practice – Karl Terzaghi and R B Peck (1967), John Wiley and Sons, NY
3. Analysis and Design of Foundations and Retaining Structures –S Prakash(1979), Sarita Prakashana, Meerut

Reference Books:

1. Soil Mechanics and Foundation Engineering – S K Garg, Khanna Publications
2. Geotechnical Engineering – C Venkataramaiah, New Age International Publishers

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Earthquake Resistant Design of Foundations

Subject Code	**16CGT251**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Focused mainly on identifying the dynamic loading induced on the foundation
- Understand soil - foundation interaction, analysis with reference to various design parameters that including liquefaction of soil due to earthquake

Modules	**Teaching Hours**
Module -1	
BASIC DESIGN PARAMETERS: Dynamic properties of soils and its evaluation, strength and deformation characteristics of soils under earthquake loading, liquefaction hazard evaluations and remedial measures, geotechnical failure of foundations during earthquake, provision of IS 1893 and IS 13920	**8 Hours**
Module -2	
Design requirements – bearing capacity theory under earthquake loading – bearing capacity analysis for liquefied soil – bearing capacity analysis for cohesive and cohesionless soils - seismic settlement of foundation.	**8 Hours**
Module -3	
Sesmic design of Pile foundations: Earthquake loading – inertial and kinematic loading - performance of piles during earthquake loading – theories of pile failure in liquefiable soils – failure based on bending mechanism/buckling instability – methods of analysis – force based or limit equilibrium method – p-y method – pile settlement - guidelines for designing of piles under kinematic loading due to liquefaction – seismic design of well/cassion foundations	**8 Hours**
Module -4	
Sesmic design of retaining walls: Introduction – Seismic passive lateral earth pressure, behaviour of retaining wall during earthquakes, modification of Coulomb's Theory, Modified Culmann's Theory, displacement analysis, Indian standard code of practice	**8 Hours**
Module -5	
Structural design of foundation: Introduction – loads acting on foundations during earthquake – fundamental failure mechanisms	**8 Hours**

of foundations – essential criteria for design of foundations in liquefiable soils – structural design of foundations subjected to earthquake loading	

Course outcomes:

During this course, students will be trained to:

- Design of foundation under earthquake loading by considering the influence of various design parameters that includes the liquefaction of soils due to earthquake.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Design of foundation in seismic areas: Principles and some applications by (2007).Bhattacharya S. (eds), Published by NICEE [National Centre for Earthquake Engineering (India)].
2. Geotechnical Earthquake Engineering (2002): Day R. W., handbook, McGraw – Hill, New York
3. Design of Pile Foundations in Liquefiable Soils (2010) Gopal Madabhushi, Jonathan Knappett and Stuart Haigh, Imperial College Press, London
4. Basic geotechnical earthquake engineering by (2008) Kamalesh Kumar, New Age International Publishers, New Delhi

Reference Books:

1. Soil dynamics (1981) Prakash, S., McGraw Hill, New York,.
2. Geotechnical Earthquake Engineering (1996), Steven L. Kramer, Prentice Hall, New Delhi,.
3. Foundation design and construction (1986), Tomilinson M.J., Longman Scientific & Technical, England,

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SEMESTER – II

Subject: Soil Structure Interaction

Subject Code	**16CGT252**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Make students understand soil structure
- understand stress-strain characteristics of soils,
- the mechanism of failure, the factors that affects the shear strength
- structural behaviour with soils

Modules	**Teaching Hours**
Module -1 Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behavior, Foundation behavior, Interface behavior, Scope of soil foundation interaction analysis, soil response models, Winkler, Elastic continuum, Two parameter elastic models, Elastic plastic behavior, Time dependent behavior	**8 Hours**
Module -2 Beam on Elastic Foundation- Soil Models: Infinite beam, Two parameters, Isotropic elastic half space, Analysis of beams of finite length, Classification of finite beams in relation to their stiffness. Plate on Elastic Medium: Thin and thick plates, Analysis of finite plates, Numerical analysis of finite plates, simple solutions	**8 Hours**
Module -3 Plates on Elastic Continuum: Thin and thick rafts, Analysis of finite plates, Numerical analysis of finite plates	**8 Hours**
Module -4 Elastic Analysis of Pile: Elastic analysis of single pile, Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap	**8 Hours**
Module -5 Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Subgrade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts. An introduction to soil-foundation interaction under dynamic loads	**8 Hours**

Course outcomes:

During this course, students will be trained to:

- Analyse the behaviour of the soil under elastic and plastic condition
- Predict the behaviour of the pile under static and dynamic loads

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Foundation analysis and design - J E Bowles, McGraw Hill, NY
2. Soil Mechanics in Engineering Practice – Karl Terzaghi and R B Peck (1967), John Wiley and Sons, NY
3. Analysis and Design of Foundations and Retaining Structures –S Prakash(1979), Sarita Prakashana, Meerut

Reference Books:

1. Soil Mechanics and Foundation Engineering – S K Garg, Khanna Publications
2. Geotechnical Engineering – C Venkataramaiah, New Age International Publishers

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[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Offshore Geotechnical Engineering

Subject Code	**16CGT253**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Understand the type of soil strata available in offshore
- Develop a structure under different environmental condition
- Design the anchors in the sea
- Design the pipelines and cable structures

Modules	**Teaching Hours**
Module -1 **DESIGN OF OFFSHORE PLATFORMS:** Introduction, fixed and floating platforms, case studies and general features, elements of hydrodynamics and wave theory, fluid structure interaction, steel concrete and hybrid platforms Consolidation and shear strength characteristics of marine sediments	**8 Hours**
Module -2	
Design Criteria: Environmental loading, wind, wave and current loads after installation, stability during towing Foundations: Site investigations, piled foundation, foundations for gravity structures, pile-supported structures	**8 Hours**
Module -3	
Behaviour under dynamic loading, static and dynamic analysis of platforms and components	**8 Hours**
Module -4	
Dynamic response in deterministic and indeterministic environment, codes of practice, analysis of fixed platform and semisubmersible related topics	**8 Hours**
Module -5	
Anchor design, breakout resistance analysis and geotechnical aspects of offshore pipeline and cable design	**8 Hours**

Course outcomes:

During this course, students will be trained to:

- Design the structure for wind, wave loads and dynamic loads
- Design the structure for overturning
- Design the pipeline and cable structures

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a

module.

- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Offshore Geotechncial Engineering – Mark Radolph and Susan Gourvenec, CRC Press.
2. Construction of Marine and Offshore Structures – Ben C Gerwick, CRC Press.
3. Offshore Geotechnical Engineering – ETR Dean

Reference Books:

1. Frontiers in Offshore Geotechnics II – Susan Gourvenec and David White, CRC Press.
2. Frontiers in Offshore Geotechnics II – Vaughan Meyer, CRC Press
3. Geotechnical Aspects of Coastal and Offshore Structures: Proceedings of the Symposium, Bangkok – A S Balasubramaniam, CRC Press

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[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject: Foundation Engineering in Difficult Ground

Subject Code	**16CGT254**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- In-situ testing in difficult grounds
- Design the foundations in earth movement conditions
- Improve the ground conditions

Modules	Teaching Hours
Module -1 **Introduction**: Classification, swelling and shrinkage, sensitivity, settlement and bearing capacity of clays, fissures in clay, glacial deposits and difficult rocks. **Site Investigation in difficult ground:** Objectives, difficulties in determining the characteristics of the ground, remedial measures	**8 Hours**
Module -2	
In-situ testing and geophysical surveying: Introduction, penetrometers, SPT, CPT, plate bearing tests, pressure meters, seismic surveying, resistivity surveying **Ground water and foundations:** Introduction, effective stress theory, oil tanks on poor ground, effect of raising the ground water level – reclaimed land, foundation on the sea bed.	**8 Hours**
Module -3	
Foundations and earth movements: Introduction, creep of rock masses, landslides, earthquake – primary and secondary effects, earthquake resistant design. **Design of foundations:** Introduction, general principles, strip and pad foundations, building on shrinkable soil, building on fill, raft foundation – variable soil and make up gound, pile foundation – choice, types; construction problems	**8 Hours**
Module -4	
Stability of slopes in difficult ground: Introduction, mechanism of stability, strength of distorted clay, factor of safety, analysis, remedial measures	**8 Hours**
Module -5	
Ground treatment: Introduction, ground water lowering techniques, electro-osmosis and electro-chemical stabilization, thermal techniques, grouts and grouting, reinforcements, other stabilization techniques, dynamic consolidation, pre loading, vibroflotation, stone columns	**8 Hours**

Course outcomes:
During this course, students will be trained to:

- Develop the in-situ methods to evaluate the bearing capacity under different criteria
- Analyse and design the grounds in shrinking areas
- Overcome the construction problems by adopting suitable methods

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Foundation in difficult ground – F G Bell, Butterworths & Co
2. Foundation Analysis and design – J E Bowles, Tata McGraw Hill

Reference Books:

1. Foundation Engineering – (2001) M J Tomlinson - PHI

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SEMESTER – I

Subject: Advanced Geotechnical Engineering Lab-2

Subject Code	**16CGTL26**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	42	Exam Hours	03

CREDITS – 02

Course objectives: This course will enable students to

- The objective of this course is to make students to learn principles and design of experiments.
- To investigate the performance of various Soils

Modules	Teaching Hours
Determination of shear strength parameters by Vane shear test	**3 hours**
Determination of shear strength parameters by CD and CU test	**3 hours**
To evaluate the bearing capacity and settlement of soils from --- by plate load test ---- by cone penetration test (static and dynamic) --- Standard penetration test	**9 hours**
To determine the ground water table --- Using electrical resistivity method --- seismic refraction method	**6 hours**
Determination of shear modulus, damping ratio and liquefaction of soils by resonant column method	**6 hours**
Determination of pH and organic solids	**3 hours**
Determination of Chemical Properties of soil such as chloride, phosphorous, Potassium, Magnesium, calcium, Sodium etc.,	**12 hours**

Course outcomes:

During this course, students will be trained :

- Achieve Knowledge of Design and development of experimental skills.
- Understand the principles of design of experiments.

Question paper pattern:

- Individual and one group experiment should be set

Text Books:

1. Shamsher Prakash, (1979) “Engineering Soil Testing”, Nemichand, New Delhi.
2. Joesph E Bowles, “Engineering Properties of soil and their measurements”, McGraw hill

Reference Books:

1. John T. Germaine, Amy V. Germaine, (2009) “Geotechnical Laboratory Measurements”, John Wiely
2. William Lambe, (2003) “Soil Testing for Engineers”, MIT.

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SEMESTER – IV

Forensic Geotechnical Engineering

Subject Code	**16CGT41**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Learning the soil properties for causing failures
- Identification of failure phenomenon
- New approach in the design aspects
- Improvisation of legal aspects in geotechnical engineering

Modules	**Teaching Hours**
Module -1 **INTRODUCTION**: Historical failures of geotechnical structures (finite and infinite slopes, high embankments such as earthen dams, tunnels, excavations, foundations-shallow and deep, retaining structures etc.), characterization of failures, Inadequateness of Limit state design, principles and advantages of Mobilizeable strength design. Numerical problems	**10 Hours**
Module -2	
TECHNICAL FORENSIC INVESTIGATION: Collection of data, problem characterization, development of failure hypotheses, a realistic back-analysis, field observations and performance monitoring, modelling of failure hypothesis and quality control of formal and technical aspects of the work. Numerical Problems.	**10 Hours**
Module -3	
GUIDELINES FOR FORENSIC INVESTIGATION OF GEOTECHNICAL CASES: Scope of the work, types of distress, diagnostic tests: field and laboratory tests, analysis, legal issues such as facts, interpretations, opinions, negligence **TECHNICAL ISSUES RELATED TO GEOTECHNICAL FAILURES:** Primary shortcomings causing failures, shortcomings in design, inadequate site investigations, unforeseen occurrences and phenomena, shortcomings in construction; recommendations to limit future occurrence of failures.	**10 Hours**
Module -4	
CASE HISTORIES: Construction of historic monuments, destruction due to environmental changes and survival of monuments among them, such as leaning tower of Pisa, Egyptian pyramids, tall structural foundations in Mexico city, pre historic caves in India etc., Consideration of geotechnical aspects such as settlement, shear strength, permeability, slope stability, etc., in construction of survived historic monuments as well as for the structures which have collapsed due to the	**10 Hours**

new adjacent constructions or disturbances due to human activities etc.,. Numerical problems	
Module -5	
GEOTECHNICAL ENGINEERING AND LEGAL SYSTEM: Legal conflict of geotechnical failures, sanctions in the legal code of construction, geotechnical work for documentation of forensic cases; case studies of legal conflict of prominent structures (such as landslides, deep excavations, unexpected settlements of oil tanks, distress in soil walls, failure due to slow creep of hills etc.)	**10 Hours**

Course outcomes:

During this course, students will be trained:

- To predict the failure modes in geotechnical engineering before construction of structures
- To design the structures to overcome the failure in geotechnical engineering by understanding the behaviour of soils
- To frame the guidelines for avoiding the legal aspects of geotechnical failures by predicting and understanding the failure mechanism, their remedial measures before the construction of the foundations.

Text Books:

1. Forensic Geotechnical and Foundation Engineering – Robert W Day (2011)
2. Forensic Geotechnical Engineering – V V S Rao and G L Sivakumar Babu (2013), Springer India

Reference Books:

1. Indo-US Forensic Practices: Investigation Techniques and Technology – Shen En Chen, R Janardhanan, C Natarajan, Ryan Schmidt (2010), American Society of Civil Engineers

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SEMESTER – IV

Optimization Techniques in Geotechnical Engineering

Subject Code	**16CGT421**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- The graduates are expected to adopt various numerical method and mathematical tools for analysis of research data
- Learning the numerical methods in applied soil mechanics
- Learning the bivariate data and Lagrangae's equation for the problems
- Application of queuing theory

Modules	**Teaching Hours**
Module -1 Recurrence Relation and Generating Functions: Formation of recurrence relation, Solution of linear and nonlinear recurrence relation, Properties of generating function and solve the recurrence relation using the generating function and related problems. Scatter Diagram; Karl Pearson's coefficient of linear correlation. , Linear regression, Properties of regression and related problem. Queue.	**8 Hours**
Module -2	
Numerical analysis: Introduction to interpolation, Newton's Forward and Backward interpolation (Statement only), Lagrange and Divided interpolation(Statement only), Simple problems. Numerical differentiation for equal and unequal interval. Matrix Eigen value and eigen vactor by power methods, simple problems. Curve fitting and problems. Statistics: Analysis of Bivariate data. Correlation Analysis – Meaning of correlation.	**8 Hours**
Module -3	
Optimization Technique: Linear programming problem (LPP) Formation of LPP, Graphical Method and related problems. Transportation Problems, assignment problem., Queuing Theory- Basic Structure, Exponential distribution, Birth-and-Death Model,	**8 Hours**
Module -4	
Tucker condition, Penalty function method, Augmented Lagrangian method, sequential unconstrained minimization, cutting plane method; Introduction to Evolutionary algorithms: Need for evolutionary algorithms, Type of evolutionary methods, Introduction to Genetic algorithm (GA), Difference and similarities between GA and traditional methods. Basic operations of GA: reproduction, crossover, mutation and elitism. Binary coded and real coded GA	**8 Hours**
Module -5	
Artificial Intelligence: Introduction- Classification of artificial intelligence-	**8 Hours**

expert systems-artificial neural networks basic concepts-uses in functional approximation and optimization applications in the design and analysis, building construction. Fuzzy logic-basic concepts-problem formulation using fuzzy logic-applications	

Course outcomes:

During this course, students will be trained to:

- Analyze the data obtained from the field
- Develop an appropriate methods to solve logically and optimize the test or field results

Text Books:

1. Introduction to Optimum Design J.S. Arora (2004), Elsevier, 2nd Edition.
2. Optimization for Engineering. Design: Algorithms & Examples K. Deb (2006), Prentice Hall India, ,
3. Engineering Optimization: Theory & Practice, S.S. Rao (2008) New Age International (P) Ltd, 3rd Edition,

Reference Books:

1. Multi - Objective Optimization Using Evolutionary Algorithms, K. Deb(2003) John Wiley
2. Applied Statistics & Probability for Engineers: Montgomery, Douglas C. & Runger, George C. (2007), 3/e,Wiley India.
3. Parallel distributed processing Vol.1 (1986) Rumelhart, D.E and McClelland, J.L.,, M I T Press, 1986.
4. Fuzzy logic implementation and applications(1996), Patyra, M.J. and Mlynek Wiley,.

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject: Reinforced Soil Structures

Subject Code	**16CGT422**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the soil suitable for reinforced earth
- Identify the type of reinforcing material suitable for the project
- Design the reinforced earth

Modules	**Teaching Hours**
Module -1 **Historical background:** Introduction to reinforced soil structures, comparison with reinforced cement concrete structures. **Reinforced Earth:** Principles, concepts and Mechanisms of reinforced earth	**8 Hours**
Module -2	
Materials used, properties, laboratory testing and constructional details, metallic strips, metallic grids, geotextiles, geogrids, geomembranes and geocomposites, their functions and design principles	**8 Hours**
Module -3	
Geotextiles: Introduction, design methods, function and mechanism, geotextile properties and test methods – physical, mechanical and hydraulic properties, construction methods and techniques using geotextiles	**8 Hours**
Module -4	
Design applications of reinforced soil structures in pavements, embankments, slopes, retaining walls and foundations, reinforced soil structures for soil erosion control problems, geosynthetic clay liners	**8 Hours**
Module -5	
Case studies of reinforced soil structures, discussion on current literature and design problems	**8 Hours**

Course outcomes:

During this course, students will be trained to:

- Design and incorporate the reinforced earth for the sites at weak soil sites
- Design the pavements, embankments using reinforced earth to enhance the engineering properties of the soils

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Designing with Geosynthetics – Koerner R H (1994), Prentice Hall Inc.
2. Reinforcements and Soil Structures – Jones, CJEP (1996), Butterworth Publications
3. Membranes in ground engineering – Rankilor, P R (1985), John Wiley & Sons.

Reference Books:

1. Soil Reinforcement with Geotextiles – Jewel R A (1996), CIRIA
2. Geotextiles hand book – Ingold J S and Miller K S (1988), Thomas Telford Ltd.

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject: Rock Mechanics

Subject Code	**16CGT423**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Identify the type of the rock
- Analyse the rock quality designation and also evaluate its strength
- Determine the methods of tunneling and mining

Modules	**Teaching Hours**
Module -1 Classification of rocks, geological petro graphic and engineering. Index properties of rocks- porosity, density, permeability, durability and slake. Core recovery, RQD and its importance in engineering Stress-strain behaviour, factors influencing the strength of rock, temperature, confining pressure, strain rates, modes of failures of rocks.	**8 Hours**
Module -2	
Failure theories of rocks Morh's hypothesis, Griffith's Criteria, Mullerl's extension of griffith's theory, elementary theory of crack propagation, failure of rock by crack propagation, effects of cracks of elastic properties. Testing of rocks: Laboratory and field test, assessment of in-situ strength	**8 Hours**
Module -3	
Rock Foundation: Shallow and deep investigation for foundation design and construction aspect, slope stability analysis, mode of failures in rock. Design of slopes, excavation in rock and stabilization concepts	**8 Hours**
Module -4	
Strengthening of rocks: Foundation treatment for dams and heavy structures by grouting and rock reinforcement. Methods and principles of grouting, principles of design of rock bolts	**8 Hours**
Module -5	
Tunnels – Basic terminology and application, site investigations, methods of excavation of tunnels supports and stabilization, construction control and maintenance, tunnel ventilation, control of ground water and gas Underground Mining; mining methods, planning and design, mining equipments and mining procedures, cause for subsidence and its remedial measures	**8 Hours**
Course outcomes:	

During this course, students will be trained to:

- Identify the type of rock and to evaluate the bearing capacity of the rock,
- Design and analyze the foundations and improvement techniques for the foundations on in-situ rocks
- Design methodologies for mining and tunneling where rock is encountered

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Introduction to Rock Mechnaics – Goodman (1976), John Wiley and Sons, NY
2. Fundamentals of Rock Mechanics – J C Jeager and N G W Cook (1976), Chapman and Hall, London
3. Geotechnology –Roberts , Pergamou Press ltd., Oxford

Reference Books:

1. Principles of Engineering Geology and Geotechniques – Krynine and Judd
2. Rock Engineering – Jhon A Franklin and Maurice b Dusseault, McGraw Hill
3. Rock mechanics for Engineers: Varma, B.P, Khanna Publishers
4. Rock mechanics & Design of structures: Obert, L & Duvall, W.I., John Wiley & Sons

SYLLABUS FOR M Tech., GEOTECHNICAL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Geotechnical Practice for Waste Management System and Ground modifications

Subject Code	**16CGT424**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Marks	80
Total Number of Lecture Hours	40	Exam Hours	03

CREDITS – 04

Course objectives: This course will enable students to

- Contamination in soils and causes for contamination
- Use of soil liners in the landfill
- understand the mechanical modifications of the soil

Modules	**Teaching Hours**
Module -1	
Introduction to waste containment, Soil system and soil-water pollution interaction, Structural components of clayey soils for landfill liner, Soil organic matter-soil minerals interaction Site investigation at polluted sites (Geophysical techniques, Hydrological investigations etc.)	**8 Hours**
Module -2	
Landfill liner system, Classification of liners and potential problems for clay barrier system, Leachate & gas collection and removal system, Leachate production and clay-leachate compatibility	**8 Hours**
Module -3	
Soil attenuation by biochemical, physical & chemical processes, Final covering system, Design of top & drainage layers, Monitoring in the saturated and unsaturated zone, Construction quality control and quality assessment, Challenges associated with landfill design & construction in tropical region	**8 Hours**
Module -4	
Mechanical modification: Introduction, principles of soil densification, properties of compacted soil and compaction control specifications for quality controls. Hydraulic modification: Introduction, objectives, techniques, Dewatering methods, soil and water relationship, Types of aquifer, Design of Dewatering systems, filtration, drainage and seepage, control, preloading and vertical drains, electro kinetic dewatering and stabilization.	**8 Hours**
Module -5	
Ground Modifications: Physical and chemical Modification: Modification by admixtures, grouting, and thermal modification. Modification by inclusions and confinement: Soil reinforcement, ground anchorage, and rock bolting soil nailing, crib walls, and gabions	**8 Hours**

Course outcomes:

During this course, students will be trained :

- to analyse and design the foundations to counter the effect of contamination of soils
- to design the soil liners and land fill
- to develop and suggest the guidelines for soil modifications

Text Books:

1. Geoenvironmental Engineering- Principles and Applications (2004): L.N. Reddy & H.F. Inyang, Marcel Dekkar
2. Geotechnical Practice for Waste Disposal (1993): D.E. Daniel Chapman and Hall, London.
3. Construction and Monitoring of Landfills (1994). A. Bagchi, John Wiley and Pone N.Y.,

Reference Books:

1. Geotechnical Engineering(2002): D.P. Coduto, Pearson Education Asia
2. Engineering Principles of Ground Modification(1990), Hausmann, M.R., McGraw-Hill International Editions
3. Ground Control and Improvement(1994), Xanthakos, P.P., Abramson, L.W. and Bruce, D.A John Wiley & Son